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TECHNICAL MEMORANDUM

No. 1126

PRESSURE-DISTRIBUTION MEASUREMENTS ON A STRAIGHT
AND ON A 35° SWEPT-BACK TAPERED WING

By A. Thiel and J. Weissinger

Translation

Deutsche Versuchsanstalt für Luftfahrt,
Institut für Aerodynamik, Deutsche Luftfahrtforschung,
Untersuchungen und Mitteilungen, No. 1293, Sept. 29, 1944.



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PRESSURE-DISTRIBUTION MEASUREMENTS ON A STRAIGHT
AND ON A 35° SWEEPED-BACK TAPERED WING*

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SUMMARY

The spanwise lift-distribution measurements in straight air flow on a straight and a 35° swept-back tapered wing (aspect ratio $\frac{b^2}{F} = 5$; taper ratio $\frac{b_1}{b_a} = 2$; NACA airfoil section 0012) are compared with theory for two angles of attack each ($\alpha \approx 6^\circ$ and $\alpha \approx 12^\circ$) in the unstalled range of flow. The complete pressure distribution for the greater of the two angles is indicated.

I. INTRODUCTION

Although the pressure-distribution measurements (announced in reference 3) on a straight wing (No. 5) and on 35° swept-back tapered wing (No. 9)¹ have been made sometime ago and are partly evaluated, the appearance of the reports of these measurements will take some time yet on account of the unusual mass of paper-work involved.

It therefore seems appropriate to publish some of the results in form of an interim report.

The measurements selected for this purpose have been very carefully worked out, but it does not preclude the

*"Druckverteilungsmessungen an einem geraden und einem 35° rückgepfeilten Trapezflügel," from Deutsche Versuchsanstalt für Luftfahrt, Institut für Aerodynamik, Deutsche Luftfahrtforschung, Untersuchungen und Mitteilungen, No. 1293, Sept. 29, 1944.

¹With and without split flaps over 50 percent and 100 percent of the span in an angle of attack range of $\alpha = -15^\circ$, $\alpha = +24^\circ$, and an angle of yaw ranging from $\beta = -30^\circ$ to $\beta = +30^\circ$.

possibility that these data might be subjected to minor changes in the final report, which might follow from the comparison of the entire test material.

II. DESCRIPTION OF THE MODEL

The two measured wings differ only in the $l/4$ -line, which is straight on wing No. 5 and swept-back 35° on wing No. 9. Without the rounded tip section the wing span is 1.5m, the mean chord $\frac{F}{b} = 0.3\text{m}$, hence an average Reynolds number of about $Re \approx 1 \times 10^6$ ($q = 156 \text{ Kg/m}^2$; $v \approx 50 \text{ m/sec}$) for the tests; the aspect ratio is $\frac{b^2}{F} = 5$, the taper ratio $\frac{l_i}{l_a} = 2$. The profile in wind direction (in straight air flow) is the NACA section 0012. The straight wing was made of improved plywood, the swept-back wing of brass. The tip rounding - aside from a certain variation on the swept-back wing - was normal, that is, semicircular with the local half profile thickness as radius. Further details may be found in references (4) and (5).

The pressure distribution was recorded with multiple manometers at $1/4$ profile sections simultaneously. While these sections are symmetrically distributed over both semispans on wing No. 5, they are all but three on one wing semispan on wing No. 9. Of the data for these three test sections XII to XIV, which merely serve for checking purposes, only those of section XII, lying closest to the wing center, are shown. The location of the section can be seen from figures 1 and 2, the percentages shown signify the distance from the plane of symmetry of the wing referred to the semispan (without tip rounding). On the straight wing, each section has 17 pressure orifices, 1 at the nose and 8 each over one another at the top and bottom side of the profile; the distances of their projections on the profile chord from the leading edge are

0, 1.75, 5, 10, 20, 40, 60, 78, and 95 percent of the profile chord. The sections II to XIV of the swept-back wing have 19 pressure stations, at

0, 1, 3, 5, 10, 20, 40, 60, 78, and 95 percent distance

of profile chord from the nose. The edge section I has 25 pressure stations the position of which is characterized by the percentages

0, 1, 3, 5, 10, 20, 40, 50, 60, 69, 78, 86.5, and 95.

A detailed description of the experimental setup and of the interpretation will be given in the principal report.

III. RESULTS

The angles of attack shown in the graphs, $\alpha = 6^\circ$ and $\alpha = 12^\circ$, refer to the tunnel axis, the angles corrected for tunnel wall interference effect and wire elongation are $\alpha = 5.7^\circ$ and $\alpha = 11.4^\circ$ for the straight wing and $\alpha = 5.8^\circ$ and $\alpha = 11.6^\circ$ for the swept-back wing. The related coefficients of the total normal force are obtained from the pressure-distribution measurements $\bar{c}_n = 0.42$ and 0.83 , and from $\bar{c}_n = 0.39$ and 0.74 .

Figures 1 and 2 represent the chordwise distribution for $\alpha \approx 12^\circ$. Conspicuous above everything else is the marked reduction of the suction peaks in the center of the swept-back wing, the center-of-pressure point of these profile sections is shifted backward by the sweepback.

Figure 3 represents the spanwise lift distributions² of both wings for $\alpha \approx 6^\circ$ and $\alpha \approx 12^\circ$. The upper left corner contains the actual measured distribution. The sweepback lowers the total lift and modifies the form of the lift distribution. To emphasize the last effect, the same distributions after dividing by the total lift are shown at the right-hand side. It shows that the sweepback shifts the center of pressure of the load toward the tip, although not as much at $\alpha \approx 12^\circ$ as at $\alpha \approx 6^\circ$ ³. In the lower part of figure 3, the distributions (referred to the same total lift) are compared with Multhopp's theory (reference 2) and Weissinger's L-method (reference 6),

²In these examples the difference between lift and normal force can be neglected.

³This phenomenon might tie in with the well known fact that with positive sweepback angle the boundary layer flows from the wing center toward the tips.

at the left for the straight, at the right for the swept-back wing. For the straight wing the two methods are not very different from each other and the measurements - apart from the lift increase which always occurs at the tip of square tipped wing are in very good agreement with the theory, which is, if the measuring accuracy admits of such minute differences at all, slightly better for $\alpha \approx 6^\circ$ by the Weissinger method, and for $\alpha \approx 12^\circ$ by the Multhopp method⁴. On the swept-back wing, on the other hand, the superiority of the L-method is (as in reference (1)) quite evident. For the identification of the point of incipient separation of flow along the span the c_a rather than the lift distributions are decisive.

Assuming for the first that the local $c_{a_{max}}$ along the span is constant, the distributions of the normal force coefficient plotted against the semispan in figure 4 indicate (especially for $\alpha \approx 12^\circ$) that the straight wing should show separation at about 0.5, the swept-back wing at about 0.7 semispan distance from the center. With the height of the suction peak over the pressure at the trailing edge divided by the local profile chord (that is, the mean pressure gradient which the boundary layer has to overcome) as rough measure for the danger of burbling, the separation should start at section V $\left(0.58\frac{b}{2}\right)$ on the straight wing, and at section III $\left(0.90\frac{b}{2}\right)$ on the swept-back wing. Added to this there is the boundary-layer travel which at the tips of the swept-back wing presumably effects a substantial damming up of boundary layer and with it increases the danger of separation (of reference (4), fig. 28).

⁴Jacobs (reference 1) established a better agreement with Weissinger's theory at all unstalled angles of attack on a straight rectangular wing.

IV. REFERENCES

1. W. Jacobs: Pressure Distribution Measurements on Swept-Back Wings of Constant Chord in Symmetrical Flow. UM 2052.
2. H. Multhopp: Application of Airfoil Theory to Problems in Flight Mechanics, Report S2 of the LGL p. 53.
3. A. Thiel, and J. Weissinger: Six-Component Measurements on a Rectangular Wing With and Without Split Flaps. FB 1729.
4. A. Thiel, and J. Weissinger: Six-Component Measurements on a 35° Swept-Back Tapered Wing With and Without Split Flaps. UM 1152.
5. A. Thiel, and J. Weissinger: Six-Component Measurements on Straight and on a 35° Swept-Back Tapered Wing With and Without Split Flaps. UM 1278.
6. J. Weissinger: Lift Distribution on Swept-Back Wings. FB 1553.

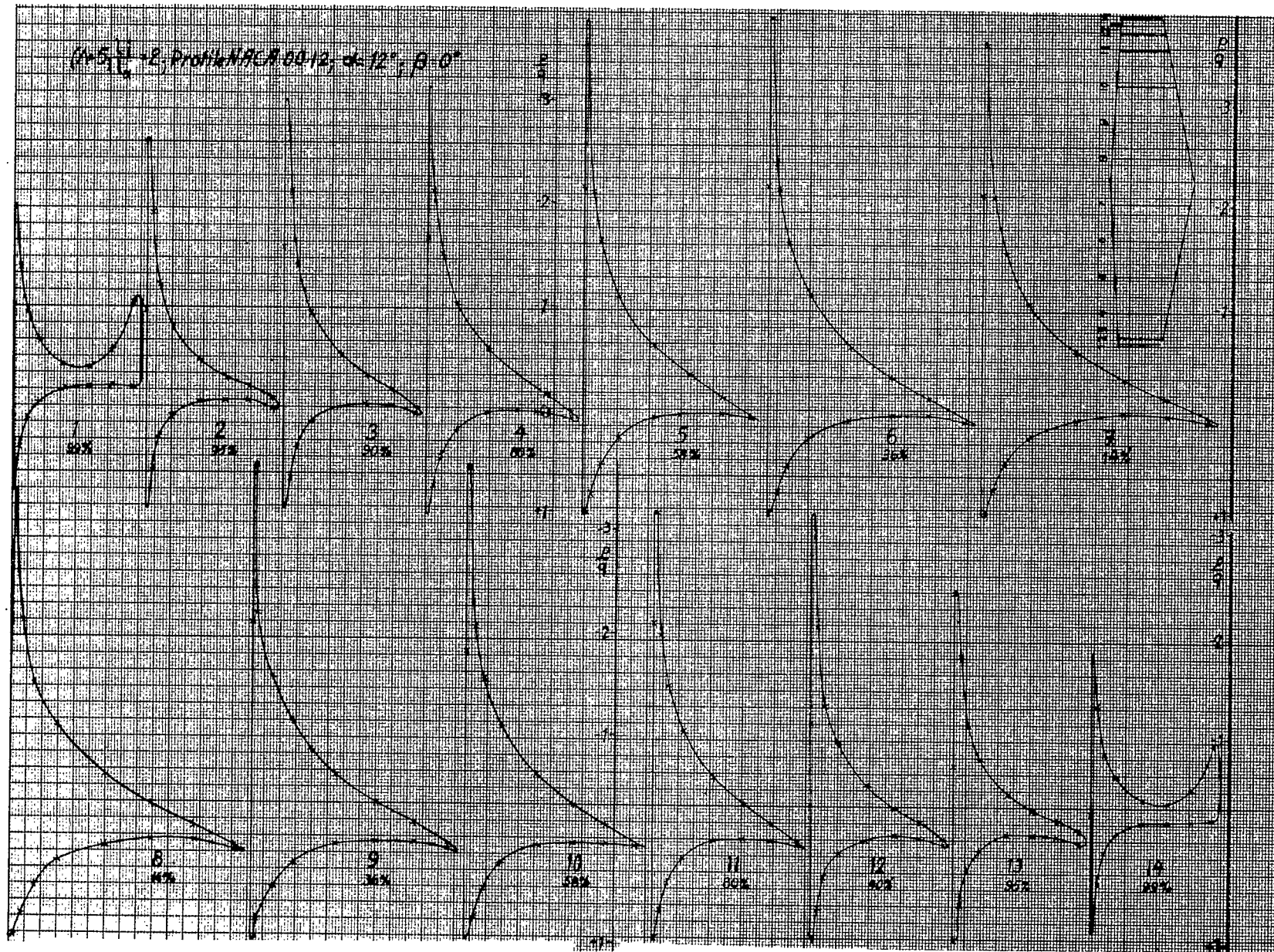


Figure 1. Pressure distribution of a straight, tapered wing.

Fig. 2

Figure 2. Pressure distribution of a 35° swept-back, tapered wing;

$(M=5.7, \frac{b}{c}=2, \text{Profile NACA 0012})$
 $\alpha=12^\circ \quad \beta=0^\circ$

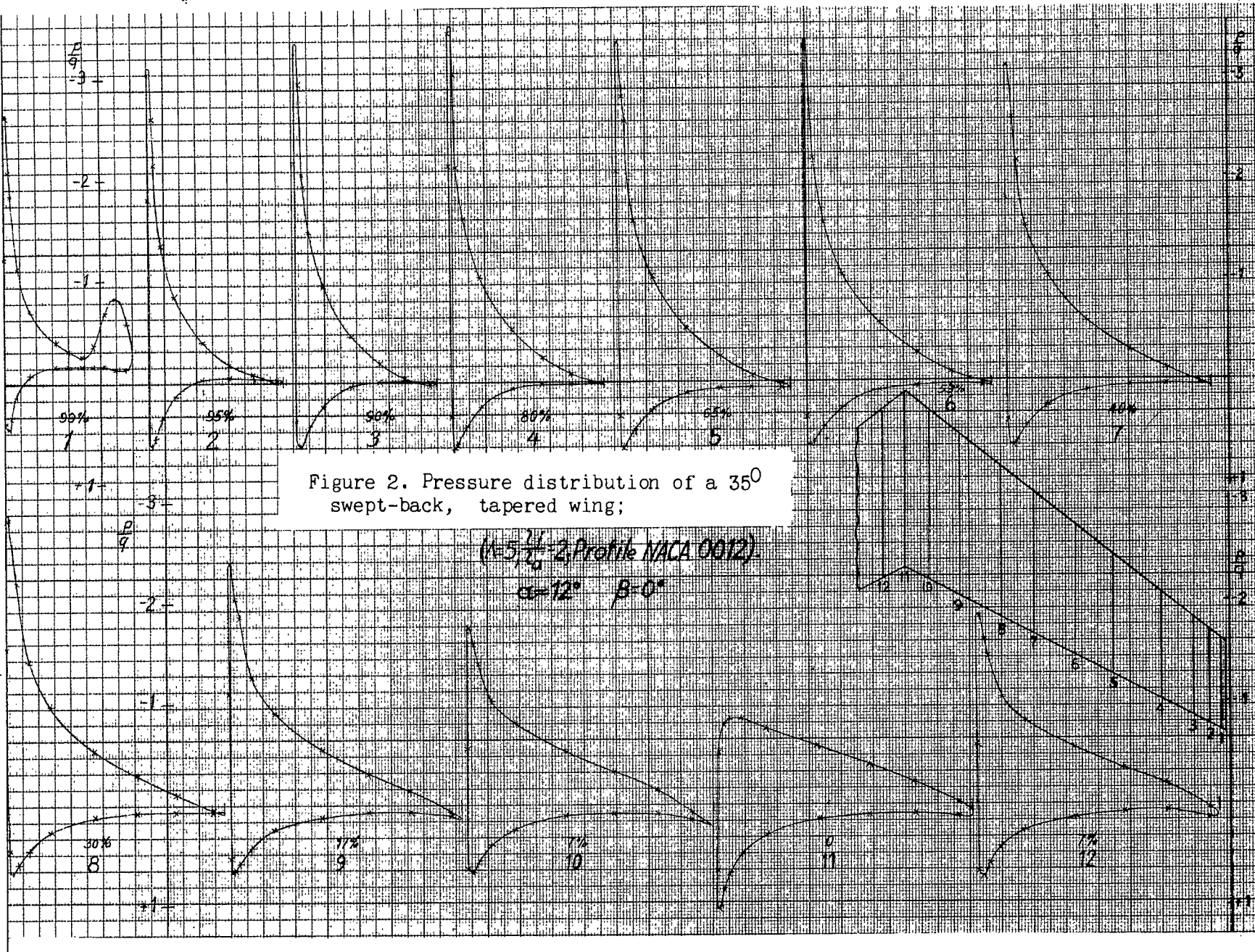
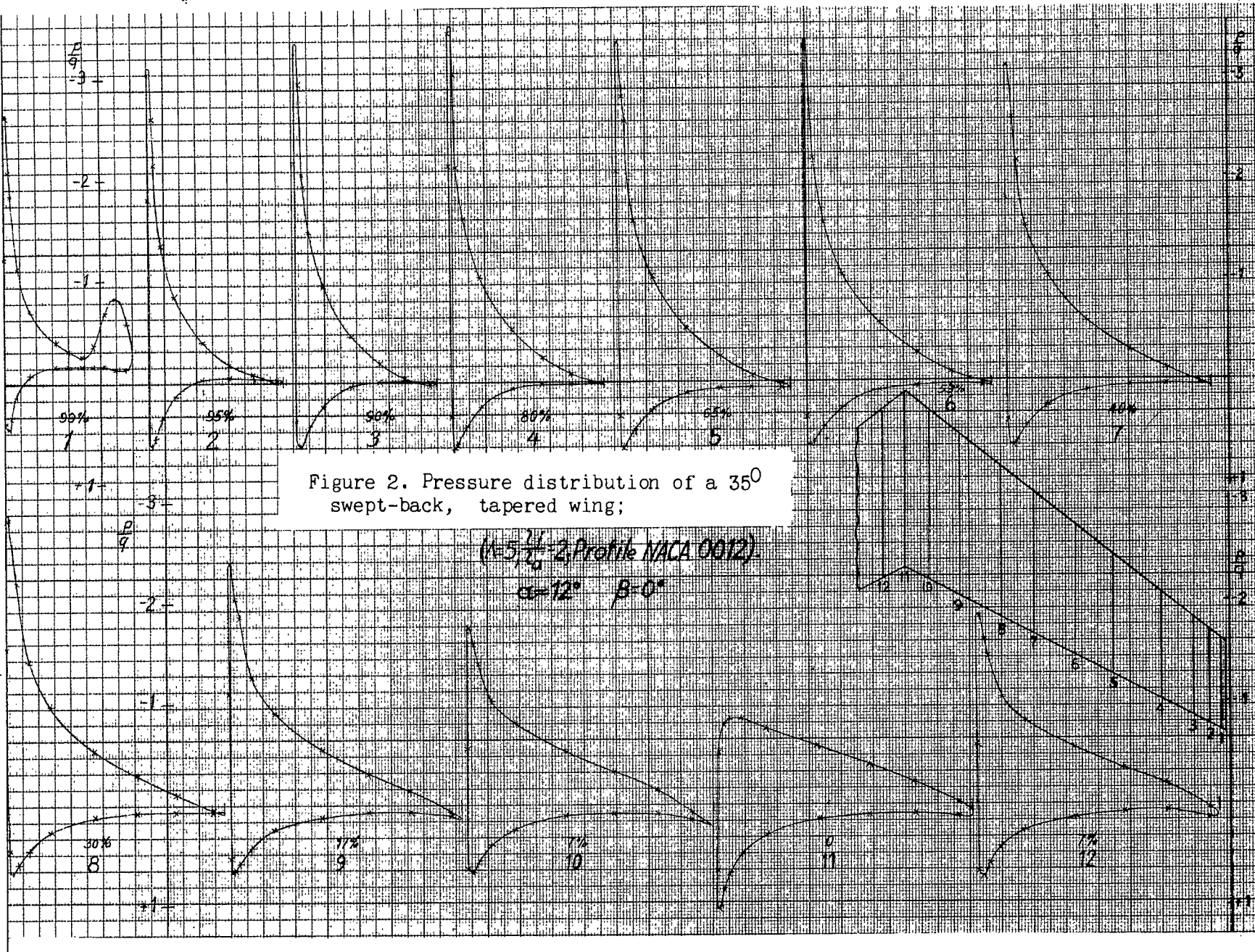


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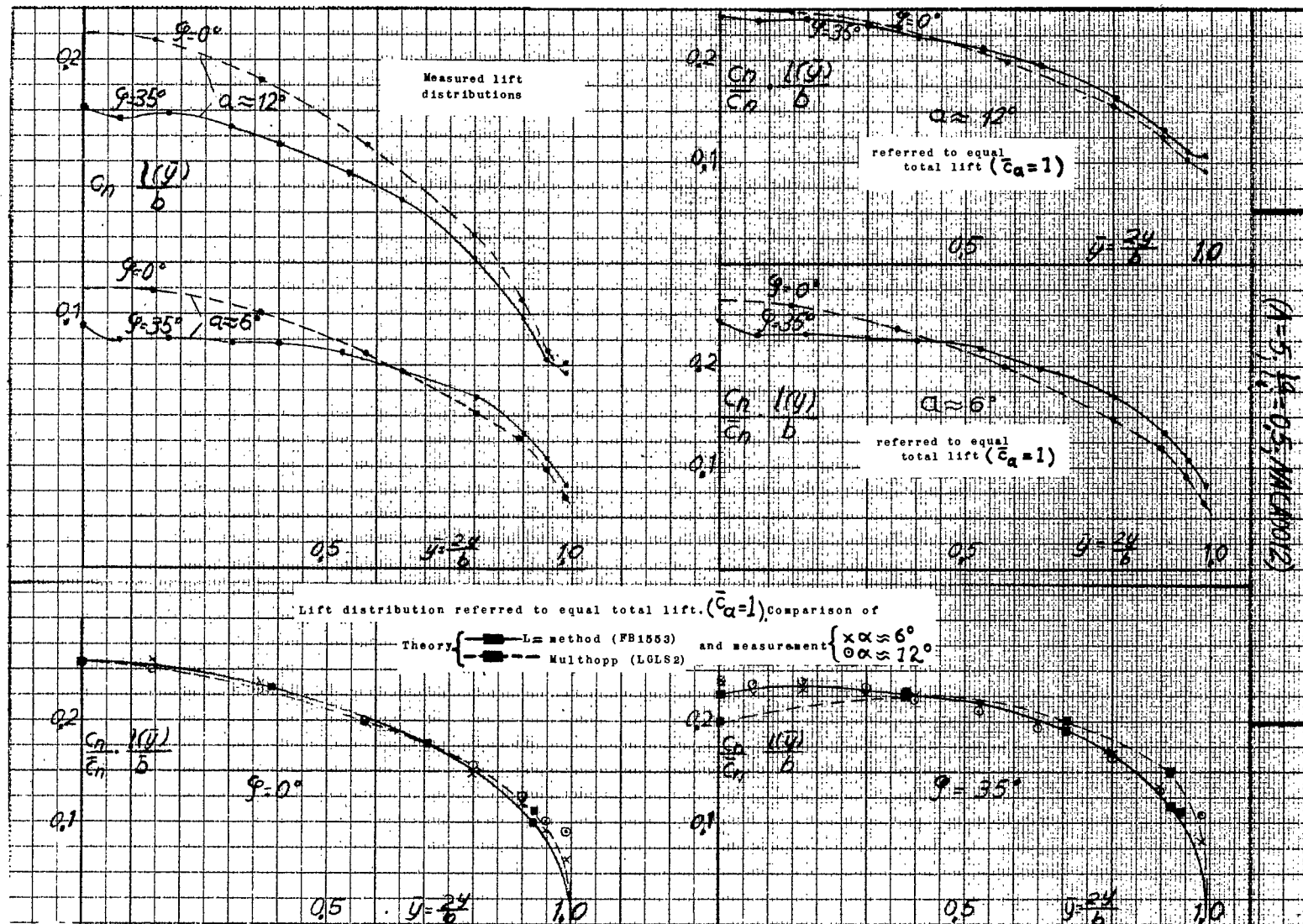


Figure 3. Lift distribution of a straight and a 35° swept-back tapered wing;

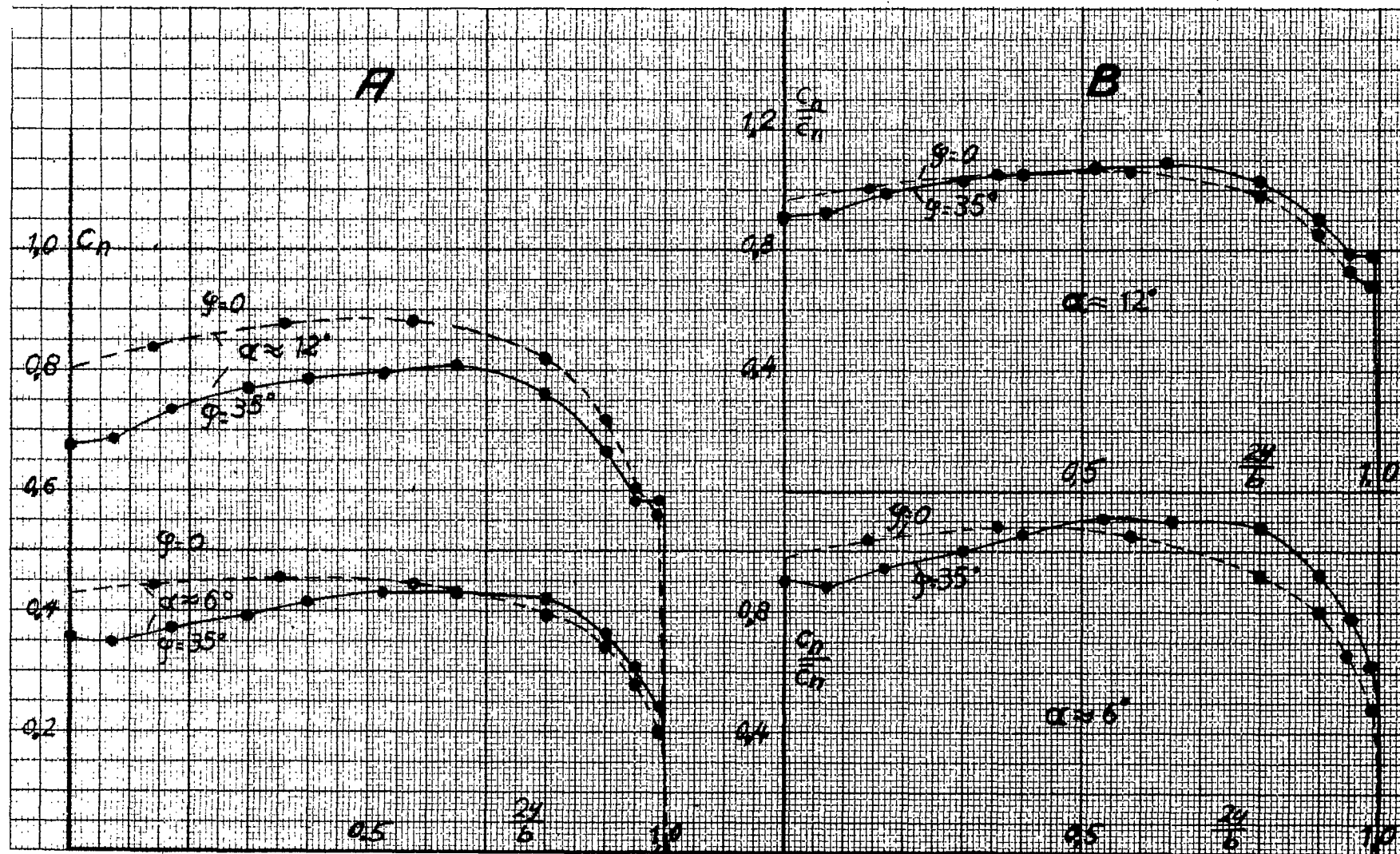


Figure 4. Distribution of normal force coefficients along the span of a straight and a 35° swept-back tapered wing.

A. Measured distributions

B. Measured distributions referred to equal total lift.